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COMPRESSION STRENGTH AND DROP TEST PERFORMANCE OF XM232 CASE ASSEMBLIES

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The MACS XM232 case must meet radial and axial compression strength requirements in order to be used in an autoloader system. This study measured XM232 radial and axial compression strengths to determine if the French proposed JBMOU requirements were met. The XM232 current design exceeds the French requirements for minimum radial compression strength of 160.5 lb with 3.5-mm deformation and minimum axial compression strength of 91.67 lb with 2-mm deformation. The XM232 case had a minimum radial strength of 199 lb and a minimum axial strength of 744 lb.

In addition to evaluation of standard XM232 cases, compression strength and drop test performance of special light weight XM232 cases were measured. Light weight cases cannot pass onangle drop test.

This report concludes that the XM232 current design meets the proposed French requirements. Manufacture of a lighter weight case will require improved case strength properties.

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CONTENTS

	Page
Objective	1
Scope	1
Experimental	1
Equipment	1
Materials	1
Case Loading and Assembly	2
Radial Compression Test	2
Axial Compression Test	2
Drop Test	3
Density	3
Results	3
Radial Compression	3
Axial Compression	3
Compression - Light Weight Cases	4
Drop Test	4
Density	4
Discussion	4
Conclusions	4
Normal Weight Results	4
Light Weight Results	5
Recommendation	5
Distribution List	15

FIGURES

		Page
1	Radial compression test for XM232 case	7
2	Axial compression test for XM232 case	7
3	XM232 case radial compression test data	8
4	XM232 case axial compression test data	9

TABLES

1	Radial compression test data	10
2	Axial compression test data	11
3	Radial and axial compression test data	12
4	Rough handling drop test data	13
5	XM232 case density	14

OBJECTIVE

The objectives of this study were:

- To determine if the XM232 case, as currently manufactured, meets radial and axial compression strength requirements proposed by the French for the JBMOU.

- To determine if a "special production" light weight type XM232 case meets rough handling requirements for straight and angle drop tests.

SCOPE

This evaluation involved radial and axial compression testing of assembled XM232 cases that had been filled with rice to simulate propellant. In addition, light weight XM232 cases were filled with a rice/gravel mixture, assembled, and drop tested.

EXPERIMENTAL

Equipment

Instron test apparatus with 8 in. diameter flat plate fixtures for compression testing

Electronic balance

Materials

Fifty XM232 case sets with normal (standard) production weight range

Twelve "special production" XM232 case sets with light weight (~84% of normal) bodies and caps

Acetone

Long grain white rice

Rock gravel, ~1/2 x 1/8 in.

Case Loading and Assembly

Fifty-six case sets were loaded with rice and assembled for compression testing (50 normal and 6 light weight). Each of the trimmed case components was weighed and labeled with an identification number. The case body components were then fitted with their respective cores. Next, each case was loaded with 1,850 g (4.1 lb) long grain white rice. The case sidewall was periodically hand tapped while loading in order to pack the rice. Then, the case set cap was inserted into the loaded XM232 body. A bead of acetone was applied at the joint of the cap and body sidewall. Following acetone bonding, the cases were allowed to dry at least 24 hrs before compression testing.

The six light weight cases used for drop testing were loaded differently than those described previously. These cases were filled with a combination of 3.5 lb rice and 1.5 lb gravel. The gravel and rice were placed in a 1 gal container and intermixed before adding to the XM232 case. The case cap was then acetone bonded in the normal manner. After the 24 hr drying period, these cases were additionally fastened by tying a string through the center core. The string was anchored at each end by threading it through a rubber stopper and tying it to a cross rod. The rubber stopper and rod both fit within the case depression and simulated the effect of tied igniter bags.

Radial Compression Test

Twenty-five of the normal production case sets and three of the light weight case sets were used for this test. Radial compression tests were carried out with the Instron apparatus. The test case was placed between steel plate fixtures as shown in figure 1. The upper plate and Instron crosshead were moved downward onto the test case until a force of 1 lb was applied. At this point, the gage length was set to zero. Next, the crosshead was moved downward at a speed of 0.1 in./min until the total travel distance was 0.138 in. (3.5 mm). The peak load, in pounds, which occurred during this downward travel was recorded.

Axial Compression Test

Twenty-five of the normal production case sets and three of the light weight case sets were used for this test. Axial compression tests were carried out with the Instron apparatus. The test case was placed between steel plate fixtures as shown in figure 2. The upper plate and Instron crosshead were moved downward onto the test case until a force of 1 lb was applied. At this point, the gage length was set to zero. Next, the crosshead was moved downward at a speed of 0.1 in./min until the total travel distance was 0.0787 in. (2 mm). The peak load, in pounds, which occurred during this downward travel was recorded.

Drop Test

Six light weight cases were used for drop testing. Three cases were used for a straight drop and three for an angle drop. In the straight drop, the case was held closed end down, parallel to the concrete floor and at a height of 7 ft above the floor. The case was allowed to fall freely to the floor and the resulting damage recorded. In the angle drop test, the case was held closed end down, at an angle of 45 deg to the concrete floor and at a height of 7 ft above the floor. The case was allowed to fall freely to the floor and the observed damage was recorded.

In addition to the light weight cases, several normal weight cases were used for drop testing. Following the radial compression test, the case sets were used for straight and angle drop testing. The axial compression test cases were damaged and not usable for drop testing.

Density

Densities of six light weight and six normal weight case sets were determined by measuring specimens from body sidewall, body closed end, and cap locations.

RESULTS

Radial Compression

Radial compression test data for normal weight cases are given in table 1. A plot of peak load versus combined body/cap weight data for the maximum 3.5 mm extension is shown in figure 3. The combination of body/cap weight was chosen for the data plot since the body and cap were the only load bearing components in the radial compression test. The combined body/cap weight range was 275.8 to 285.4 g. The current production weight specification for the trimmed body/cap combination is 280 ±25 g. Analysis of combined body/cap data and peak load data by a Shapiro-Wilk's test indicated that both data sets are normally distributed.

Axial Compression

Axial compression test data for normal weight cases are given in table 2. A plot of peak load versus body weight data for the maximum 2-mm extension is shown in figure 4. Body component weight was chosen for this plot since the load is supported by only the body component in the axial compression test. Trimmed body component weight range was 202.4 to 213.2 g. The current production weight specification for trimmed body components is 210 ± 15 g. Analysis of body component and peak load data by a Shapiro-Wilk's test indicated that both data sets are normally distributed.

Compression - Light Weight Cases

Radial and axial compression test data for light weight cases are given in table 3. The data are also shown graphically in figures 3 and 4, respectively.

Drop Test

Case component weight data and results for cases used in the rough handling drop tests are given in table 4. Light weight cases passed the straight drop test, but failed the angle drop test.

There were no failures in the straight or angle drop tests for the normal weight cases which were tested following radial compression. It should also be noted that the weight loading for these cases (4.1 lb rice) was slightly lower than the weight loading for the light weight cases (5.0 lb rice/gravel).

Density

Density data are given in table 5. The lighter weight cases had densities 16 to 20% lower than normal weight cases. Caps for both light and normal weight cases had densities approximately 12% higher than their respective body components.

DISCUSSION

The XM232 case easily met the proposed radial and axial compression strength requirements for the autoloader system. Data for the light weight cases showed that both radial and axial compression strength are significantly reduced when case density is decreased. Therefore, the strength characteristics should be reevaluated if any adjustments to case density are made.

Rough handling drop test data showed that light weight cases pass the straight drop, but fail the angle drop. In the angle drop, failure occurred at the closed end radius. The impact created separations large enough to permit release of both rice and gravel. This radius appears to be a weak point and its strength should be improved if lighter cases are manufactured.

CONCLUSIONS

Normal Weight Results

The XM232 charge has passed rough handling tests, both individually and in packed form. This series of tests was conducted to see if the XM232 case meets the

proposed radial and axial compression strength requirements for autoloader use. To reflect gravatational acceleration, the compression strength requirements were revised to:

- Radial - maximum deformation of 3.5 mm under a load of 700 N (160.5 lb)
- Axial - less than 2 mm deformation under a load of 400 N (91.67 lb)

Light Weight Results

The light weight XM232 cases were specially fabricated for this series of tests. These light weight cases passed the rough handling straight drop test, but failed the rough handling angle drop test.

RECOMMENDATION

The XM232 case, as currently manufactured, can withstand a radial compression load of 700 N (160.5 lb) with less than 3.5 mm deformation and an axial compression load of 400 N (91.67 lb) with less than 2 mm deformation.

If lighter weight XM232 cases are manufactured, the strength of the closed end radius will need to be improved in order to meet rough handling angle drop test requirements.

Figure 1
Radial compression test for XM232 case

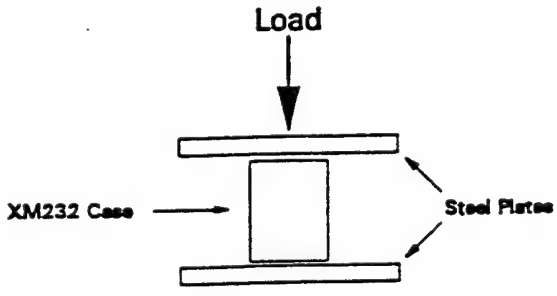

Figure 2
Axial compression test for XM232 case

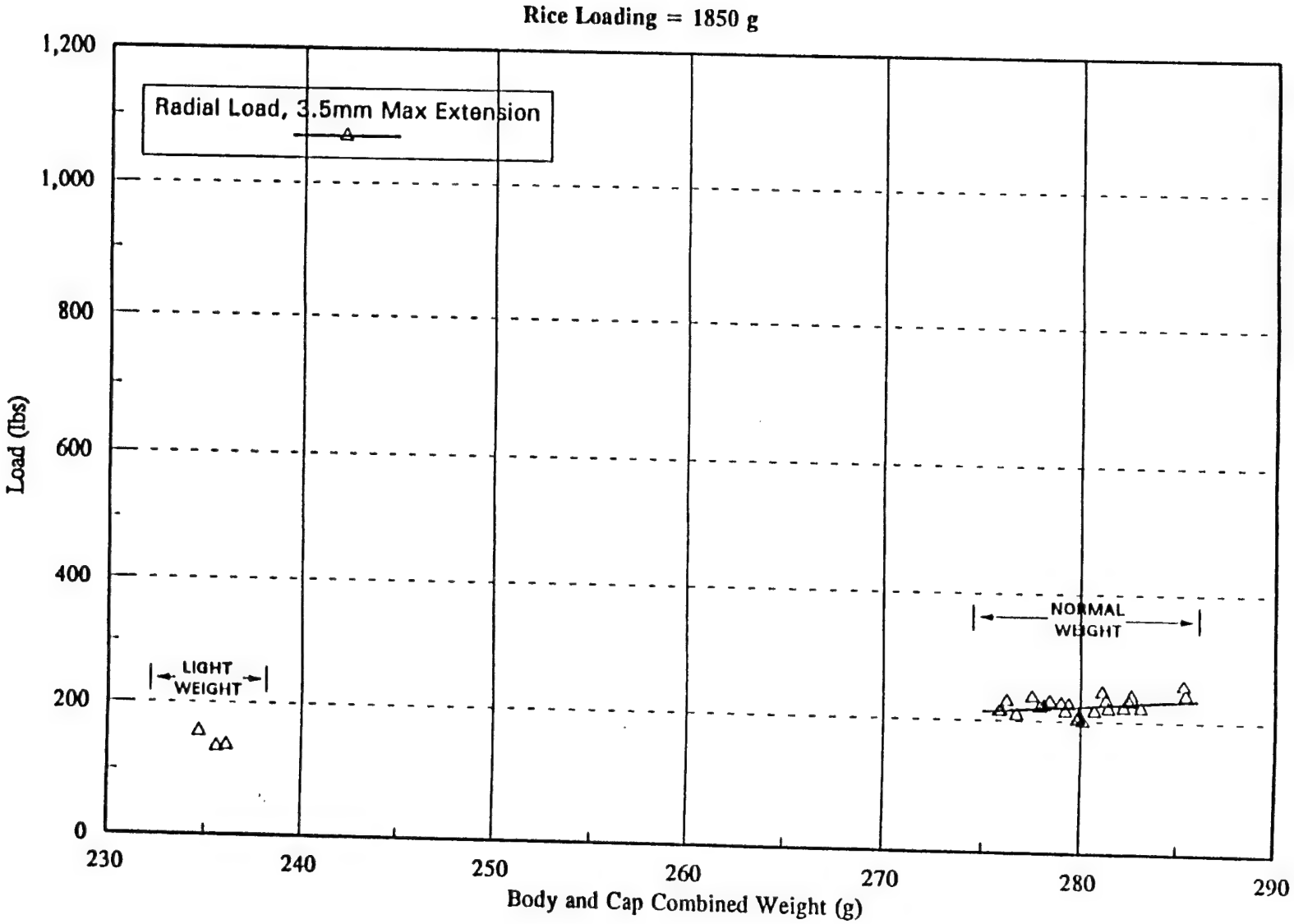

Figure 3
XM232 case radial compression test data

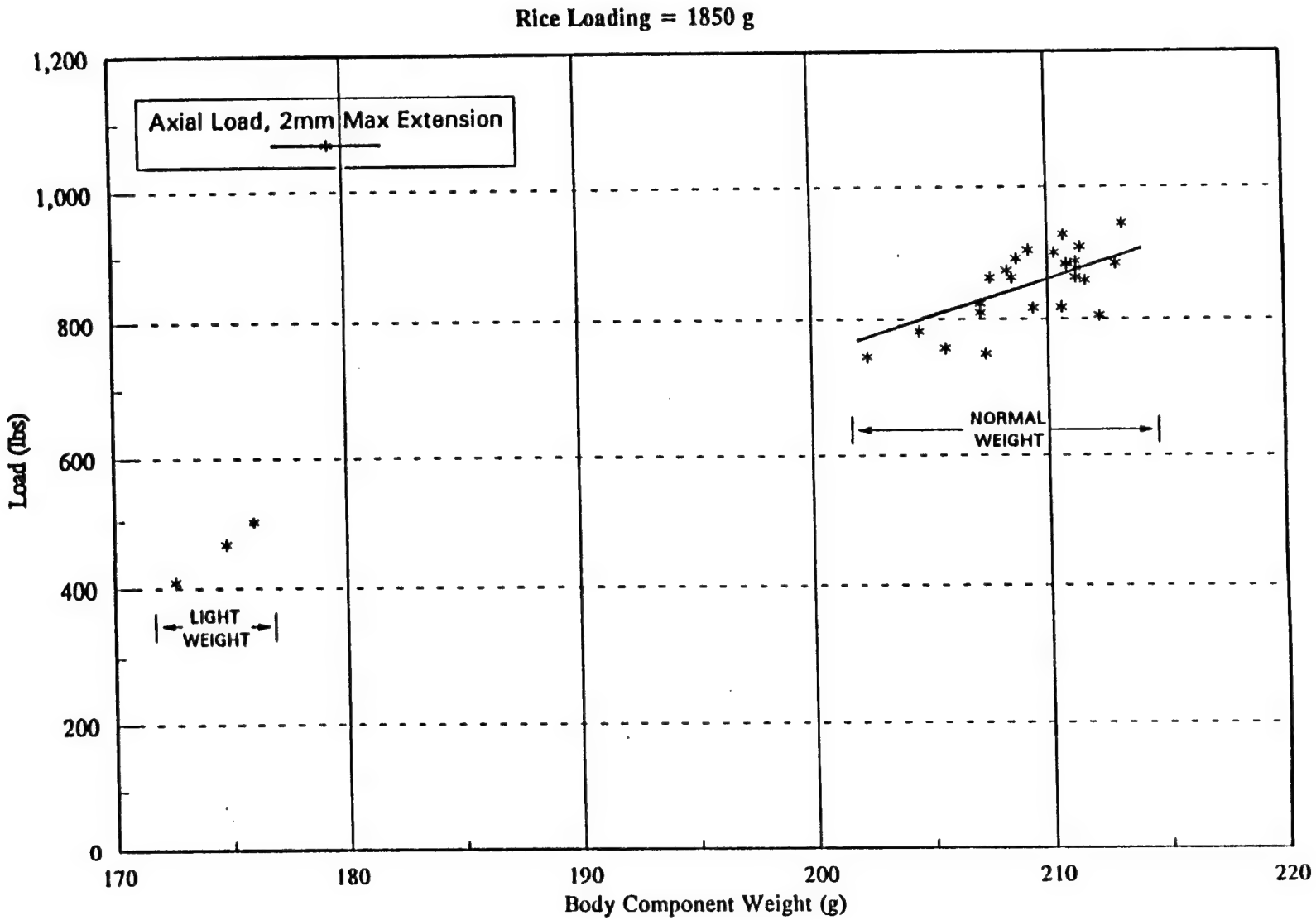

Figure 4
XM232 case axial compression test data

Table 1
Radial compression test data

NORMAL WEIGHT CASES

Body Batch # 90516
Cap Batch # 90516
Core Batch # 62403

Case Set #	Cap Wt (g)	Body Wt (g)	Core Wt (g)	Body + Cap Wt (g)	Peak Load (lbs)
B – 1	71.0	207.1	18.0	278.1	221.5
2	71.6	207.4	18.4	279.0	226.1
3	69.9	212.3	18.2	282.2	219.9
4	69.7	206.2	18.3	275.9	214.0
5	69.9	213.2	18.2	283.1	219.9
6	72.6	212.7	18.1	285.3	254.8
7	71.6	207.6	18.1	279.2	213.7
8	70.9	208.9	18.4	279.8	201.1
9	71.4	209.9	18.6	281.3	231.4
10	68.4	207.8	17.9	276.2	229.0
11	71.7	207.7	18.9	279.4	224.4
12	71.9	205.6	18.4	277.5	235.4
13	71.1	211.4	18.2	282.5	229.3
14	71.4	207.0	18.0	278.4	229.0
15	71.6	208.5	17.8	280.1	198.9
16	70.8	207.1	18.1	277.9	219.3
17	70.5	212.1	17.8	282.6	238.7
18	70.2	205.6	18.4	275.8	213.2
19	72.6	207.3	18.1	279.9	202.7
20	70.4	206.3	17.9	276.7	208.1
21	72.4	208.3	17.6	280.7	214.0
22	71.6	209.5	18.2	281.1	244.3
23	71.0	214.4	18.2	285.4	240.0
24	70.0	209.9	18.2	279.9	207.5
25	71.4	210.0	17.8	281.4	218.3
Range				275.8 – 285.4	198.9 – 254.8
Average				280.0	222.2
Standard Deviation				2.6	13.7

Table 2
Axial compression test data

NORMAL WEIGHT CASES

Body Batch # 90516
Cap Batch # 90516
Core Batch # 62403

Case Set #	Cap Wt (g)	Core Wt (g)	Body Wt (g)	Peak Load (lbs)
A – 1	71.5	18.2	209.4	817.2
2	67.3	18.0	211.4	909.8
3	71.3	18.6	210.8	885.1
4	71.3	17.7	212.2	805.6
5	72.0	18.1	211.2	888.1
6	71.3	18.2	210.3	901.5
7	72.2	18.3	211.2	877.6
8	72.0	17.8	210.8	883.2
9	71.1	18.1	205.7	756.8
10	70.8	18.5	207.4	748.5
11	70.0	18.1	209.2	905.2
12	71.7	18.1	211.6	859.3
13	69.8	17.8	211.2	863.6
14	70.9	18.2	210.7	928.9
15	72.7	18.0	202.4	744.2
16	69.8	17.4	208.3	874.1
17	71.5	18.2	208.7	892.4
18	70.5	17.8	207.6	863.1
19	71.5	18.3	204.6	781.8
20	71.1	18.5	210.6	817.7
21	70.0	17.9	213.2	945.5
22	68.7	18.3	212.9	884.8
23	71.6	18.3	207.2	809.7
24	71.5	18.3	208.5	863.4
25	72.1	17.8	207.2	823.9
Range			202.4 – 213.2	744.2 – 945.5
Average			209.4	853.2
Standard Deviation			2.6	54.5

Table 3
Radial and axial compression test data

LIGHT WEIGHT CASES

Body Batch # 90517
Cap Batch # 90517
Core Batch # 62402

Test	Case Set #	Cap Wt (g)	Core Wt (g)	Body Wt (g)	Body + Cap Wt (g)	Peak Load (lbs)
Axial	C – 1	58.8	17.9	172.6	---	408.3
Axial	2	59.5	18.5	174.8	---	462.8
Axial	3	59.2	18.6	176	---	498.3
	Range			172.6 – 176.0		
	Average			174.5		
	Standard Deviation			1.4		
Radial	4	59.2	18.6	175.5	234.7	155.4
Radial	5	59.4	18	176.7	236.1	135.3
Radial	6	58.9	18.5	176.7	235.6	133.2
	Range				234.7 – 236.1	
	Average				235.5	
	Standard Deviation				0.6	

Table 4
Rough handling drop test data

LIGHT WEIGHT CASES

Body Batch # 90517
Cap Batch # 90517 & 90520
Core Batch # 62402

Drop Test	Case Set #	Cap Wt (g)	Body Wt (g)	Core Wt (g)	Assembly Wt (g)	Results
Straight	D – 1	59.0	172.8	18.5	250.3	Pass
Straight	2	58.6	176.3	18.6	253.5	Pass
Straight	3	59.4	173.9	18.7	252.0	Pass
Angle	4	59.4	174.1	18.8	252.3	Fail
Angle	5	59.4	175.1	18.2	252.7	Fail
Angle	6	58.9	173.8	18.6	251.3	Fail
	Range				250.3 – 253.5	
	Average				252.0	
	Standard Deviation				1.0	

Table 5
XM232 case density
Normal weight versus light weight cases

Normal Weight Sidewall Specimens

Sample #	Density (g/cc)
B- 2 -S1	0.949
-S2	0.950
-S3	0.946
-S4	0.960
B- 12 -S1	0.928
-S2	0.933
-S3	0.956
-S4	0.932
B- 15 -S1	0.945
-S2	0.961
-S3	0.946
-S4	0.960
B- 22 -S1	0.969
-S2	0.972
-S3	0.967
-S4	0.954
B- 24 -S1	0.936
-S2	0.959
-S3	0.965
-S4	0.958
B- 25 -S1	0.958
-S2	0.921
-S3	0.965
-S4	0.958
Range	0.921 - 0.961
Average	0.953
Standard Deviation	0.015

Light Weight Sidewall Specimens

Sample #	Density (g/cc)
D- 1 -S1	0.779
-S2	0.777
-S3	0.783
-S4	0.809
D- 2 -S1	0.788
-S2	0.804
-S3	0.806
-S4	0.806
D- 3 -S1	0.788
-S2	0.797
-S3	0.789
-S4	0.793
D- 4 -S1	0.786
-S2	0.779
-S3	0.800
-S4	0.792
D- 5 -S1	0.803
-S2	0.800
-S3	0.778
-S4	0.812
D- 6 -S1	0.791
-S2	0.813
-S3	0.781
-S4	0.792
Range	0.769 - 0.813
Average	0.793
Standard Deviation	0.012

Normal Weight Case Bottom Specimens

Sample #	Density (g/cc)
B- 2 -B1	0.949
-B2	0.948
B- 12 -B1	0.952
-B2	0.955
B- 15 -B1	0.938
-B2	0.926
B- 22 -B1	0.995
-B2	0.970
B- 24 -B1	0.986
-B2	0.994
B- 25 -B1	1.000
-B2	0.997
Range	0.926 - 1.000
Average	0.968
Standard Deviation	0.025

Light Weight Case Bottom Specimens

Sample #	Density (g/cc)
D- 1 -B1	0.760
-B2	0.756
D- 2 -B1	0.788
-B2	0.783
D- 3 -B1	0.752
-B2	0.760
D- 4 -B1	0.804
-B2	0.811
D- 5 -B1	0.782
-B2	0.772
D- 6 -B1	0.785
-B2	0.775
Range	0.752 - 0.811
Average	0.774
Standard Deviation	0.018

Normal Weight Cap Specimens

Sample #	Density (g/cc)
B- 2 -C1	1.075
-C2	1.057
B- 12 -C1	1.088
-C2	1.085
B- 15 -C1	1.079
-C2	1.056
B- 22 -C1	1.056
-C2	1.058
B- 24 -C1	1.035
-C2	1.032
B- 25 -C1	1.078
-C2	1.081
Range	1.032 - 1.088
Average	1.067
Standard Deviation	0.020

Light Weight Cap Specimens

Sample #	Density (g/cc)
D- 1 -C1	0.871
-C2	0.866
D- 2 -C1	0.864
-C2	0.858
D- 3 -C1	0.899
-C2	0.891
D- 4 -C1	0.915
-C2	0.912
D- 5 -C1	0.910
-C2	0.901
D- 6 -C1	0.877
-C2	0.856
Range	0.856 - 0.915
Average	0.885
Standard Deviation	0.021

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